Strategies to document active learning practices in biology

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ABSTRACT: The Centre of Excellence in Biology Education (bioCEED) was awarded its status as a Norwegian Centre of Excellence in Education by NOKUT in 2014. Among bioCEED's goals is to develop and spread new pedagogical practices for biology, while creating a Scholarship of Teaching and Learning (SoTL) culture in the faculty. In order to establish a baseline understanding of teaching practices, collaborators collected data on instructor and student self-reported behaviors, and applied the Classroom Observation Protocol for Undergraduate STEM (COPUS) to video-captured lectures in one department (BIO) at one institution (the University in Bergen). In addition, students completed surveys on confidence, motivation, and their perceptions of how class time was spent in individual courses. We found that biology instructors use a diversity of in-class techniques to engage their students and, when self-reporting, underestimate their use of evidence-based teaching. Also, upper-level, small-enrollment courses are perceived by students as being more student-centered than are the larger, introductory-level courses. We conclude by recommending (a) the implementation of low-stakes, formative assessment (such as a classroom-response system) in large-lecture classes, and (b) the continued use of the COPUS and student surveys to track changes due to bioCEED activities.

Keywords: scientific teaching, active learning, Classroom Observation Protocol for Undergraduate STEM (COPUS), Teaching Practices Inventory (TPI)

1 INTRODUCTION

The Centre of Excellence in Biology Education (bioCEED) was awarded its status as a Norwegian Centre of Excellence in Education by NOKUT in 2014. Among bioCEED's goals is to develop and spread new pedagogical practices for biology, while creating a Scholarship of Teaching and Learning (SoTL) culture in the faculty. Central to bioCEED's mission is the broad implementation of evidence-based teaching, itself aligned with a larger movement in education called "Scientific Teaching" (ST). ST is a teaching paradigm supported by copious evidence and endorsed by numerous science-teaching organizations (1,2,3,4). ST has a tri-fold emphasis on Active Learning, Assessment, and Diversity, three areas that can inform bioCEED's overall discipline-based educational research, or DBER, mission. We focus here on the use of active learning strategies in courses offered through the Department of Biology at the University of Bergen, where bioCEED is housed.

Active Learning refers to educational strategies that involve the students in constructing their own knowledge (e.g., 5, 6). Active learning strategies include immediate feedback techniques (e.g., classroom-response systems), problem-based learning, case studies, worksheets (completed individually or in groups), think-pair-share discussions, strip sequences, and so on. The incorporation of active learning techniques into traditional course formats has been supported by numerous studies, touting the efficacy of active learning in increasing student performance in Science, Technology, Engineering and Math (STEM) courses (7).

As departments and programs, such as bioCEED, promote the use of evidence-based teaching practices, they face the challenge of documenting the impact of these changes on their faculty and students (8,9). Traditional reporting metrics, such as student evaluations of teaching, may not be designed to measure pedagogical strategies so much as instructor reliability, perceived fairness, or enthusiasm for the material (10,11). Thus, there has been a recent interest in improved metrics for gauging teacher practices and teacher-student interactions, with an emphasis on those in-class behaviors shown to be related to improved student learning and engagement (e.g., 9, 12, 14, 15, 16). Our primary goal in this work was to measure the use of evidence-based teaching practices in one biology department (BIO) at one institution (the University in Bergen) in Norway. We employed two of these instruments—the Classroom Observation Protocol for Undergraduate STEM (COPUS; 12, 13) and the Teaching Practices Inventory (TPI; 16)—as well as a student survey, created in-house, to take a snapshot of the current state of teaching practices in BIO. Secondarily, for a sample of courses, we measured the extent to which students, instructors, and classroom observers align, in assessing how class time is organized.

2 METHODS

2.1 The Classroom Observation Protocol for Undergraduate STEM

The Classroom Observation Protocol for Undergraduate STEM (COPUS) was developed to collect objective information about how faculty are constructing class time, and how students are responding to instructor behaviors (6, 7). The COPUS involves classroom observers, recording, at two-minute intervals, instructor and student coded behaviors from a list of typical in-class actions. Instructor behaviors include, but are not restricted to, the following (with codes):

- Posing a general question (nonrhetorical, nonclicker) to all students (PQ)
- Asking a clicker[*] question (CQ)
- Lecturing (Lec)
- Moving through the class and guiding student work (MG)

Student behaviors include the following:

- Answering the instructor's question (AnQ-S)
- Discussing a clicker question in groups (CG)
- Listening to the instructor (L)

To measure in-class behaviors for BIO courses, faculty were asked to participate by allowing us to video-record several class sessions during Spring 2016. All sessions were recorded mid-semester, in February and March. Students were informed about the study prior to recording, and gave consent to be recorded, with the guarantee of anonymity and the deletion of all video files at the conclusion of the study.

Videos were housed on a secure external hard-drive, accessible only by project staff and trained observers. Eight students (in fields outside of biology) were trained in one, two-hour session, using sample video available via the Carl Wieman Science Education Initiative (CWSEI) at: http://www.cwsei.ubc.ca/resources/files/COPUS_Training_Protocol.pdf. Following this training, each video was scored by two observers to calculate inter-rater reliability (IRR). At the end of the first day, IRR exceeded 90% for all paired comparisons, and students resumed scoring independently. Codes were averaged to give a multi-class view of each course.

2.2 The Teaching Practices Inventory

The Teaching Practices Inventory (TPI; 16) is a standardized tool that allows faculty to self-report their instructional practices—both in and out of the classroom environment. By responding to a series of questions, an instructor can, in 10-15 minutes, get an "extent of use of research-based teaching practices," or ETP, score. A higher ETP score indicates an instructor who employs a substantial number of evidence-based teaching practices in his or her course. Evidence-based teaching can include out-of-class behaviors (e.g., providing students with a list of specific competencies to be gained from the course), in-class behaviors (e.g., encouraging small-group discussion on project work), and feedback (e.g., using answer keys or grading rubrics for transparency).

bioCEED administrators emailed faculty in BIO, requesting assistance with the TPI project. Faculty members were ensured that TPI results were not meant to be evaluative, and would be used in combination with other metrics to illuminate teaching practices in the department. Surveys were completed online during a two-week period in February, 2016.

[*] In this case, "clicker" question can refer to any question answered by a personal-response device, which can be a hand-held remote (e.g., "iclicker"), an application on a web-enabled device such as a cell phone or tablet (e.g., Poll Everywhere, TopHat), or a system of numbered, patterned or colored cards (e.g., plicker).

2.3 Survey

Lastly, a *survey* was administered to students enrolled in thirteen different biology courses during the mid-point of the semester. This survey met the needs of several independent investigations (on student confidence, motivation, background, etc.), and included a few new items designed to gather student perceptions of how class time was spent in the individual biology courses. For example, students were asked to rate their agreement with various statements, such as "The teacher designs meaningful in-class activities" and "I am actively engaged in learning during class." Responses are derived from five-point, Likert-scale items in which 1=Never and 5=Essentially all the time. Responses were averaged to detect trends, and course-level responses were combined to detect, using one-way ANOVAs and F-tests, differences between introductory (100-level), intermediate (200-level), and advanced (300-level) courses. Students were informed of the goals of the study, as well as their ability to omit any or all survey items. Each student consented to participate in the study.

The research on human subjects (surveys and video-recording) was approved by NSD Prosjektnr 46727.

3 RESULTS

3.1 The Classroom Observation Protocol for Undergraduate STEM

The Classroom Observation Protocol for Undergraduate STEM (COPUS): 10 instructors, representing 8 courses, agreed to participate by allowing their classes to be video-recorded. Six of these courses were recorded at least twice (and COPUS scores reflect averages); two of the courses were recorded once. Most class sessions were 75 – 90 minutes, resulting in approximately 20 hours of class time recorded and scored. Figure 1 summarizes the in-class behaviors of these ten instructors; figure 2 summarizes the in-class behaviors of the students in the corresponding courses.

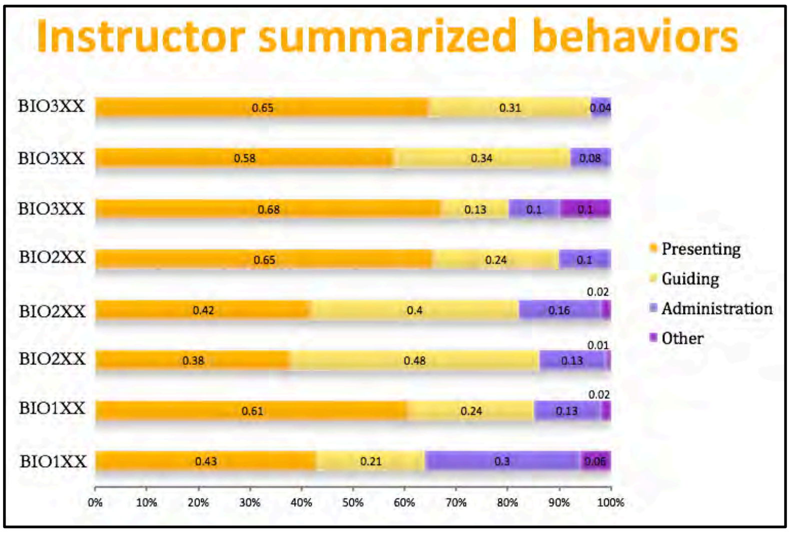

Figure 1. A summary of instructor behaviors for eight classes in the Department of Biology. COPUS codes have been collapsed into the following behavioral categories: **Presenting** (includes: Lecturing, Real time Writing, and Demos/Videos); **Guiding** (Follow Up, Posing Question, Clicker Question, Answering Question, and Moving/ Guiding); **Administration** (Assigning homework, handing out tests etc.); and **Other** (Waiting and Other).

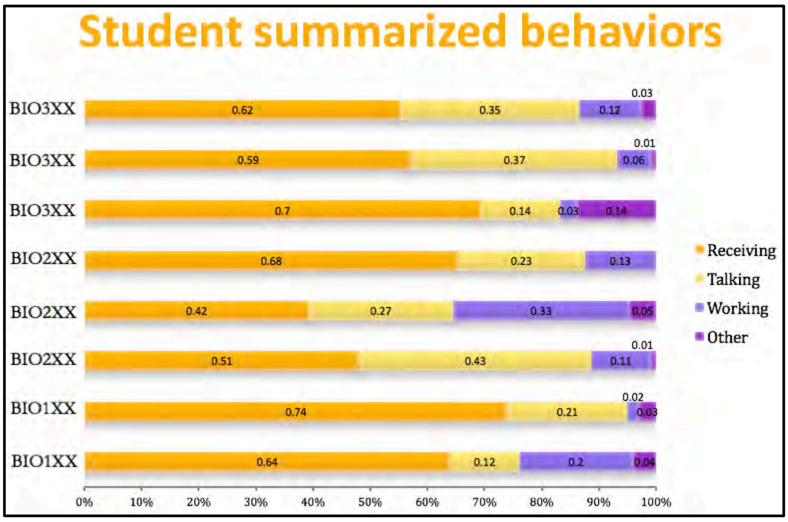

Figure 2. A summary of student behaviors for eight classes in the Department of Biology. COPUS codes have been collapsed into the following behavioral categories: **Receiving** (Listening), **Talking to Class** (Answering Questions, Asking Questions, Whole Class discussion, Student Presentation), **Working** (Individual thinking, Discussing Clicker Questions, Working in Groups, Other Assigned Group Activity, Predicting, Taking a Test or Quiz), and **Other** (Waiting and Other).

3.2 The Teaching Practices Inventory

The Teaching Practices Inventory (TPI). Response rates to the TPI were low, with eleven faculty members participating (representing fewer than one-half of those contacted initially). This may reflect a general concern with the TPI (personal observation), namely that, by collapsing an instructor's teaching into a single number to reflect "evidence-based" teaching practices, the tool cannot escape being viewed as evaluative. In the interests of preserving anonymity (with such a small sample size), and discouraging the perception of the TPI as being evaluative, we restrict our comments to the following: of the five faculty members who participated in both the TPI and the classroom observations, all of their assessments of how much time they spend lecturing (versus doing other things in class) exceeded the times reflected in the COPUS scores. For example, one instructor chose the option "60-80%" to characterize the proportion of class time he typically lectures, whereas the COPUS scores reflected 42% for the category "Presenting"—which includes lecturing. Another chose the "60-80%" option, and lectured at most 38% of the time. Also, on open-ended comments about transforming teaching, many faculty express a willingness to approach their teaching with a scientific lens (developing and testing hypotheses, collecting and analyzing data, etc.), but express concerns about lacking the capacity (time, resources, knowledge of "how to begin") to do so.

Response item	**100-level (n=42)**	**200-level (n=42)**	**300-level (n=19)**
**I discuss course material with the teacher outside of class	1.69	2.17	2.42
The teacher lectures in class	4.1	3.68	3.94
***I lead discussions in class	1.38	1.93	2.42
***The teacher designs meaningful in-class activities	2.55	3.31	3.37
*The teacher asks questions to gauge our understanding during class	3.03	3.6	3.58
***I volunteer answers in class	1.8	2.56	3.05
***The teacher asks questions to stimulate thoughtful discussion during class	2.71	3.53	3.58
***The teacher designs meaningful assignments for out-of-class work	2.17	3.49	3.47
I think about class material outside of class	3.78	3.77	3.58
I listen carefully in class	4.07	3.84	4.26
**The instructor discusses why the material is useful or interesting from my (the student's) perspective.	2.95	3.3	3.79
I try very hard in class	3.68	3.56	3.95
I pay attention in class	4.12	4.05	4.42
I enjoy learning new things in class	4.15	4.14	4.37
*Class is fun	3.21	3.47	3.89
I am actively engaged in learning during class	3.29	3.44	3.95
***The teacher seems interested in my learning	2.98	3.68	3.89
***The teacher gives timely feedback on my performance in class	1.79	2.72	3.06
*I look forward to attending class	3.29	3.56	4

Table 1. Average student response, by course level, to several items related to their, and their instructor's, course-related behaviors. Responses are derived from five-point, Likert-scale items in which 1=Never and 5=Essentially all the time. Averages were compared for significant differences across categories using one-way ANOVAs. P-values reflect the probability of exceeding a given Sum of Squares F-ratio. *$p<0.05$; **$p<0.01$; ***$p<0.001$.

3.3 Survey

Survey response was low, at ~25% of enrolled students responding to an email request to complete an online survey. For some 300-level courses, which enroll upper-division students, there were fewer than three responses. For interpreting general trends, courses were combined into 100-level courses (including three large-enrollment courses and 42 survey respondents), 200-level courses (including four medium-enrollment courses and 42 respondents), and 300-level courses (including six small-enrollment courses and 19 respondents). These combined response averages are depicted in Table 1.

Across the board, students report relatively high levels of listening in class, thinking about course material outside of class, trying hard, paying attention, and enjoying learning new things. Where there are differences by course level, the patterns indicate a more student-centered environment in the higher-level, smaller-enrollment courses: students in 300-level courses are more likely than their 100-level counterparts, for example, to report that they lead discussions in class, that the teacher designs meaningful in-class activities, and that the teacher seems interested in the students' learning.

4 DISCUSSION

This work, with its limited focus on one department at one Norwegian institution, is clearly limited in scope. Any interpretation is further restricted by the low response rate of teachers to the TPI and of students to the online survey. However, despite these limitations, certain themes emerge. First, it is clear that these biology instructors use a diversity of in-class techniques to engage their students (Figure 1), and, when self-reporting, underestimate this diversity—reporting lecturing more than they actually do. This tendency to under-report what instructors no doubt perceive as desirable instructional practices may reflect a Scandinavian tendency not to boast—a tendency encapsulated in the cross-Scandinavian "Law of Jante," which affirms that the individual is not to commit any of several offenses, including thinking he or she is better than anyone else (17). For example, one study (18) implicated *Janteloven* in a pronounced difference between Danish and U.S. teachers' self-efficacy. However, other factors may also be at play, such as confusion over the exact meaning of "lecturing;" for example, does writing on the board count as lecturing? What about giving a demonstration? These behaviors are associated with the same passive student behaviors (Figures 1 and 2), however are not, strictly speaking, lecturing.

Second, students in these biology courses perceive the upper-level, small-enrollment courses as being more student-centered than do their counterparts in the larger, introductory-level courses. These findings are not necessarily surprising, as others (e.g., 19, 20) have reported on the challenges of incorporating active, student-centered learning into the large-lecture setting. However, some of the disparities—such as the use of questions to stimulate thoughtful discussion, or the delivery of timely feedback—could be addressed by evidence-based strategies. For example, a classroom-response system, or CRS (e.g. TopHat, Poll Everywhere, etc.), can be easily implemented to both stimulate discussion and give immediate feedback on a student's conceptual understanding (21-23). Given that, on the TPI, instructors all expressed a willingness to learn more and try new things, this department's 100-level courses may be the ideal venue for whole-scale implementation (with adequate support) of a CRS. We predict that a thoughtfully employed CRS would mitigate some of the disparities in student-centered instruction that currently exist between introductory and advanced biology courses.

In conclusion, we find, for this population, utility in the COPUS and student surveys in gauging the implementation of active-learning techniques. The TPI was of limited utility, largely due to low response rate, which may reflect instructor concerns about the evaluative nature of the instrument, as well as concerns about anonymity. We also found good alignment between the self reports of instructors and students, and the objective ratings of in-class behaviors.

The COPUS is relatively new, however it has been tested in several North American institutions, ranging from Maine and British Columbia (12) to Nebraska (24) and Washington State (25). We are unaware of COPUS implementation outside of North America, but anticipate its continued use at this institution, as departmental faculty increase the use of active learning techniques in several biology courses.

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